

Docket No.: WBW-13903

C E R T I F I C A T I O N

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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5                   **Device For Illuminating Tooth Surfaces**  
6                   **And Human Skin**

9           The invention relates to an attachment according to the preamble  
10          of claim 1.

11  
12          Illuminating devices for, in particular, uneven surfaces, e.g.  
13          the surfaces of teeth, are known. Aside from the mere illumination  
14          of tooth surfaces, among other things, illuminating devices of  
15          this type are used to support or enable the use of detection  
16          instruments, e.g. image recording, image generating or image  
17          transmitting units. With the aid of detection devices of this  
18          type, surface properties, for example the colour, can be measured.  
19          Thus, for example, when the colour of teeth is measured, the  
20          respective tooth is illuminated and an electronic image of the  
21          tooth is taken with subsequent determination of the colour by means  
22          of an intraoral camera or the like.

23  
24          To be able to obtain a clear, qualitatively good and expressive  
25          image or a clear colour impression, it is advantageous to exclude  
26          all reflections or interruptive influences as much as possible.

27          For this purpose, numerous attachments are known which can be  
28          mounted or placed on detection units or intraoral cameras of this  
29          type. Such attachments generally have an annular contact surface,  
30          optionally of a soft material, with a round or circular aperture.

31          The attachment is placed against the test surface, whereby the  
32          properties of the test surface surrounded by the aperture is  
33          measured by the detection unit. The medium air is thereby found  
34          between the detection unit and the test surface.

35  
36          The object of the invention is to provide an advantageous  
37          alternative to the conventional illumination of surfaces, for  
38          example, of surfaces of teeth, leather, skin, lacquer, textiles,  
39          materials or the like, whereby an attachment is proposed which  
40          is designed according to the characterizing part of claim 1. This  
41          enables, facilitates or improves a measurement or detection of  
42          surface properties, e.g. colour, roughness, reflection property,

1 structure, etc.

2

3 By designing the conductor as a solid component or present as a

4 solid body, greater pressure can be applied to the test surface.

5 By using a pad, it is attained that the attachment can be adapted

6 to all unevennesses of the surface and can fill them as much as

7 possible. This synergistic effect ensures that no gaps or only

8 the smallest quality-reducing gaps remain between the test surface

9 and the attachment.

10

11 Furthermore, it is ensured that the test surface, e.g. the dental

12 enamel or the gums, is not damaged by the soft and optionally

13 elastic pad.

14

15 Moreover, scattering effects during the light transmission is

16 minimized and the light can be conducted from the light source

17 almost free of loss to the test surface.

18

19 Moreover, an optimal, full surface illumination is obtained.

20

21 In this connection, it is advantageous if the materials of the

22 conductor are selected according to the features of claims 2 and

23 3. It is thereby attained that the conductor is stable and durable

24 and withstands the pressure exerted and that the pad can be

25 carefully applied to the test object with a close fit.

26

27 An advantageous alternative to the design of the pad is implemented

28 in the features of claim 5. The pad is not only soft and flexible,

29 but can also be easily replaced.

30

31 An advantageous design of the conductor which is both inexpensive

32 and simple to produce is described in the features of claim 6.

33 With this design, the pressure can be selectively applied or acted

34 upon at certain points to a specific area of the test surface.

35 Moreover, the advantageous design of the attachment prevents a

36 partial reduced illumination, shading or shade formation from

37 occurring in the central measuring range of the test surface, in

1 particular due to the detection unit or the camera. In this way,  
2 the test surface is illuminated essentially uniformly over the  
3 entire surface and almost free of a camera shadow or shadings.

4

5 As a result of a suitable material selection, such as  
6 advantageously described in claim 4, the shadow formation is  
7 reduced even more in that the light rays are broken toward the  
8 centre and, as a result, the dimensions of the shaded surface are  
9 additionally reduced.

10

11 An advantageous variation of the production of the attachment is  
12 noted in the features of claim 7.

13

14 To obtain a high-quality image which is uniformly illuminated,  
15 it is advantageous if the features of claim 8 are provided.

16

17 To prevent the formation of creases or interruptive air gaps  
18 between the pad and the conductor, it is advantageous if the feature  
19 of claim 9 is used. This results in an optimal adaptation of both  
20 parts of the attachment to one another.

21

22 To prevent distortions as much as possible, it is advantageous  
23 if the features of claim 10 are implemented.

24

25 For improved handling or mounting of various devices, e.g. lighting,  
26 detection units, etc., it is advantageous if the features of claim  
27 11 are used. This is also a very simple solution from a structural  
28 point of view.

29

30 To generate diffused light, the feature of claim 12 can be  
31 advantageously provided.

32

33 To obtain optimal image quality or illumination quality, it is  
34 advantageous if the light source or the detection unit according  
35 to claims 13 and 14 are used.

36

37 The features of claim 15 represent a simple handling and effective

1 solution from a structural point of view.

2

3 A further variation of the arrangement of light source and  
4 detection unit is described in the features of claim 16.

5

6 To obtain as sharp and high-contrast or high-detailed image as  
7 possible, it is useful or advantageous to apply the features of  
8 claim 17.

9

10 An advantageous design or use or a device in which the attachment  
11 is advantageously used is shown in claim 18.

12

13 Further advantages and designs of the invention are found in the  
14 description and the attached drawings.

15

16 The invention is schematically illustrated with reference to  
17 embodiments in the drawings and is described by way of example  
18 in the following with reference to the drawings.

19

20 Fig. 1 shows a perspective representation of the attachment.

21

22 Fig. 2 shows a section through the attachment including lighting  
23 and detection unit.

24

25 Fig. 3 shows a section through the attachment including carrier  
26 part and measuring instruments.

27

28 Fig. 4 shows a section through an alternative embodiment of an  
29 attachment.

30

31 Fig. 1 schematically shows the construction of an attachment 1  
32 according to the invention. The position of the attachment 1 or  
33 the detection unit 15 with respect to the test surface 10 to be  
34 measured can be seen in Fig. 2.

35

36 The attachment 1 comprises a conductor 2 and a pad 3. The conductor  
37 2 has an essentially flat light-admission surface 6 facing the

1 light source 21 or the detection unit 15 and an optionally flat  
2 light-exit surface 4 facing the test surface 10. The conductor  
3 in the form of a solid body consists of a transparent, preferably  
4 homogeneous, colourless and/or optically clear first material  
5 which can be described as hard and rigid when used as directed.

6 Materials which are suitable for this are, for example, glass  
7 or plastic, preferably polymethyl methacrylate, polycarbonate,  
8 polyamide, styrene acrylonitrile (SAN), polystyrene, sealing  
9 compounds or casting resins based on epoxide resin, polyurethane  
10 resin, organo-polysiloxan or the like, in particular with a  
11 ball-pressure hardness of >100 measured according to ISO 2039-1.

12

13 Advantageously the rotary-like conductor 2 has the geometric shape  
14 of a body with an upper part 11 in the form of a cylinder or a  
15 parallelepiped, in particular a rectangular parallelepiped, and  
16 a lower part 12 molded to or adjoining it in one piece in the area  
17 of the light exit or light-exit surface 6 with its base  
18 centrosymmetrically to the median axis 14, said lower part 12 being  
19 in the form of a cone, a truncated cone or a cone with a rounded  
20 tip, a pyramid, etc.

21

22 The conductor 2 may also consist of two pieces, namely of the upper  
23 part 11 and the attached lower part 12, whereby the upper part  
24 11 and the lower part 12 preferably have an equally large and  
25 similar connecting or basal surface. The upper part 11 and the  
26 lower part 12 could be connected to one another in a  
27 material-locking manner, in particular refraction-free, in  
28 particular by gluing with a transparent, optically clear adhesive  
29 which preferably has a refractive index that lies between the  
30 refractive indices of the upper part 11 and the lower part 12.

31

32 The outer surfaces of the conductor 2 can be polished.

33

34 The flanks of the lower part 12 have a slope angle  $\alpha$  of maximum  
35  $60^\circ$ , in particular of maximum  $53^\circ$ , preferably of maximum  $45^\circ$ . As  
36 a result of this inclination, a shadowing, in particular by the  
37 detection unit 15, of the central area about the median axis 14

1 is prevented and a distortion is kept as low as possible when the  
2 tip 7 of the conductor 2 is raised from the surface of the test  
3 object 10 to be measured.

4

5 A transparent, preferably homogeneous, colourless and/or  
6 optically clear pad 3 is attached to the conductor 2 or to the  
7 light-exit surface 4 of the conductor 2, said pad adjoining the  
8 light-exit surface 4 in a form-locking and optionally  
9 material-locking manner.

10

11 This pad 3 may be in the form of a solid body and consists in this  
12 case of a transparent, preferably homogeneous, colourless and/or  
13 optically clear second material which has a hardness that is less  
14 than the first material, i.e. which is softer than the first  
15 material. In particular, a ductile, pliant, flexible and/or  
16 elastic material, preferably having a shore hardness of <40,  
17 measured according to the A-scale or having a penetration of a  
18 150g-heavy needle by 0.1mm, is used for this purpose, for example,  
19 silicone or silicone derivatives or polyurethanes. The pad 3 is  
20 advantageously soft in a gel-like manner, however, it does not  
21 dissolve.

22

23 Alternatively, the pad 3 can be made as a transparent, preferably  
24 colourless and/or optically clear hollow body whose preferably  
25 very thin casing is formed from a ductile, flexible and/or elastic  
26 material or a foil, e.g. of silicone or a silicone derivative or  
27 polyurethane, and which is filled with a transparent, preferably  
28 homogeneous, colourless and/or optically clear medium, e.g. a  
29 liquid or a gel, in particular water, a sodium chloride solution,  
30 etc.

31

32 The pad 3 advantageously has a recess or formation complementary  
33 to the lower part 12 of the conductor 2 for accommodating the  
34 conductor 2 or the lower part 12. This prevents a crease formation  
35 or deformation when the conductor 2 is joined with the pad 3 and  
36 interruptive air pockets are more or less excluded. A recess of  
37 this type is obtained by molding or casting via a pattern or mold

1 or by casting or molding directly on or to the conductor 2. In  
2 this way, the pad 3 is adapted to or connected to the conductor  
3 2 in a form-locking or material-locking manner.

4

5 Due to the elastic formation of the casing in a construction of  
6 the pad 3 as a filled hollow body, the lower part 12 can penetrate  
7 into the pad 3 and the casing adjoins the light-exit surface 4  
8 of the lower part 12 in a tight, air-pocket free and sealed manner.

9

10 On the one hand, the pad 3 can be connected with the conductor  
11 2 by direct molding or gluing, in particular in a refraction-free  
12 manner, with a transparent, optically clear adhesive which  
13 preferably has a refractive index that lies between the refractive  
14 indices of the upper part 11 and the lower part 12, whereby it  
15 can be sufficient if it is not glued over the entire surface but  
16 only at a few points, in particular four points in the peripheral  
17 area. It can also suffice that the pad 3 is merely pressed onto  
18 the lower part 12 and the adhesion is great enough that the pad  
19 3 remains in its position.

20

21 To obtain optimal results, it is advantageous if the tip 7 of the  
22 lower part 12 or of the conductor 2 ends essentially in a common  
23 plane with the preferably continuous surface of the pad 3 facing  
24 the test object 10. The tip 7 can thereby also project through  
25 a small hole, in particular on the median axis 14, of the pad 3  
26 in direction of the test surface 10. Distortions and blurredness  
27 is prevented as much as or as extensively as possible.

28

29 When in use, the attachment 1 with the pad 3 is placed against  
30 the test surface 10 to be measured and sufficient pressure applied.

31 The pad 3 should be adapted to the shape or structure or profile  
32 of the surface as much as possible. Air pockets between test object  
33 10 and pad 3 should be excluded, if possible, as they might affect  
34 the quality of the image.

35

36 After measuring, the pad 3 remains dependent on the material,  
37 either in its shape and does not adapt to the new surface until

1 the next measurement, or it is sufficiently elastic that it returns  
2 to a neutral shape or to its initial position.

3  
4 With a pad 3 designed as a filled hollow body, the tip 7 of the  
5 lower part presses on the pad 3, as a result of which the liquid  
6 or the gel is displaced and the tip 7 of the test surface 10 is  
7 not only separated by the two positions of the casing of the pad  
8 3 in the extreme case. However, due to the very slight thickness  
9 of the casing, this distance to the test surface can be disregarded  
10 and does not affect the measurement results.

11  
12 The conductor 2 and/or the pad 3 can be designed as a disposable  
13 item for a single use or made washable or sterilizable and thus  
14 be reusable. It is also possible to just exchange the pad 3 and  
15 to place a new pad 3, e.g. fastened with a contact adhesive, onto  
16 the conductor 2 prior to each measurement.

17  
18 It is advantageous if the refractive index of the conductor 2 is  
19 greater than the refractive index of the pad 3. As a result, light  
20 rays emanating from the light source 21 are broken when passing  
21 from the conductor 2 to the pad 3 in direction of the median axis  
22 14, i.e. toward the centre. This reduces a shadowing of the central  
23 area.

24  
25 When the pad 3 is formed as a filled hollow body, the light rays  
26 are also broken toward the centre by the filling with a medium  
27 having a refractive index that is less than that of the conductor  
28 2.

29  
30 The light rays of the light source 21 pass either directly from  
31 the light source 21 through the conductor 2 or they are held at  
32 the lateral walls of the conductor 2, in particular the upper part  
33 11, by total reflection inside the conductor 2. An optionally  
34 one-sided, inward pointing reflective coating of the surfaces of  
35 the conductor 2, in particular the upper part 11, is also possible.

36  
37 As can be seen in Fig. 3, a carrier part 13 can be fastened or

1 clamped in the area of the light-admission surface 6 of the  
2 conductor 2. One possibility for attaching and fixing is the  
3 formation of a notch or groove 20 in the upper part 11 of the  
4 conductor 2 which preferably extends about the entire periphery  
5 of the conductor 2. A plurality of devices can be fastened or  
6 accommodated on or in this carrier part 13, e.g. a diffusing lens  
7 19, the light source 21, the detection unit 15, in particular an  
8 intraoral camera, a handle 16, etc.

9

10 The diffusing lens 19 is advantageously provided on or in front  
11 of the light-admission surface 6 of the conductor 2 between the  
12 light source 21 and the light-admission surface 6 and can be glued  
13 or mounted either on the light-admission surface 6 or it is fastened  
14 to or in the carrier part 13.

15

16 The diffusing lens 19 may be a prism foil or an optical lighting  
17 film. The light of the light source 21 is scattered through it  
18 and diffused.

19

20 The light source 21 is advantageously arranged in the centre or  
21 in a circular form about the median axis 14 of the conductor or  
22 in front of the light-admission surface 6. The light source 21  
23 may consist of several individual light sources, in particular  
24 light diodes (LEDs), or it can be formed by a luminous disk or  
25 surface.

26

27 The detection unit 15 is provided on or in front of the  
28 light-admission surface 6. Detection unit 15 refers to an  
29 image-recording and/or image-generating or image-transmitting  
30 device, in particular a video camera, e.g. an intraoral camera  
31 or a CCD chip. The detection unit 15 is advantageously fastened  
32 in the middle or centrosymmetrically to the median axis 14 or in  
33 the area of the carrier part 13. An advantageous arrangement is  
34 that the detection unit 15 is surrounded in a circular manner by  
35 the light source 21. This arrangement is often used in commercial  
36 intraoral cameras to obtain optimal illumination.

37

1 A handle 16 can be fastened to the carrier part 13, whereby the  
2 handle 16 is either securely connected to the carrier part 13 or  
3 can be easily mounted and taken off or can be clipped on. The  
4 light source 21 and/or the detection unit 15 can be integrated  
5 in the top of the handle 16, if possible in the handle 16, namely  
6 in particular in the top of the handle 18 inserted in the carrier  
7 part 13 or mounted on it. In the event that a light source 21  
8 is mounted on the attachment 1, a recess 17 can be formed in the  
9 carrier part 13 through which the conductor 2 is in an optically  
10 conducting connection with the detection unit 15 and/or the light  
11 source 21.

12

13 It is also possible that the detection unit 15 and/or the light  
14 source 21 are external devices which are in an operative or  
15 optically conducting connection with the conductor 2 via a  
16 reflector system or optically conducting system arranged inside  
17 the handle 16. Optical conductors, e.g. glass fiber lines, which  
18 conduct the light from an external light source 21 into the  
19 attachment 1 or the conductor 2 are also feasible.

20

21 The light of the light source 21 used is preferably white light,  
22 however, UV light and/or light of other selected wavelengths or  
23 wavebands can also be used.

24

25 To take the focal length of the detection unit 15, in particular  
26 the intraoral camera, into consideration, it is useful and  
27 advantageous that the height H of the conductor 2 which is measured  
28 from the light-admission surface 6 to the tip 7 of the lower part  
29 12 corresponds to the focal length of the detection unit 15.

30

31 A further embodiment of the invention according to Fig. 4 provides  
32 that the angle  $\alpha$  of the lower part 12 is  $0^\circ$ , i.e. that the conductor  
33 2 has the form of the upper part 11 or is reduced to the form of  
34 the upper part 11. The pad 3 is installed or fastened to the flat  
35 light-exit surface 4 of the conductor 2 in a form-locking or  
36 material-locking manner. The height of the attachment 1, measured  
37 from the light-admission surface 6 of the conductor to the surface

1 of the pad 3 facing away from the conductor 2 should correspond  
2 to the focal length of the detection unit 15. Above all, this  
3 embodiment is advantageously used when using a diffusing lens 19.